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NWP related activities in AUSTRIA

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1. Operational systems

AROME-Aut (2.5 km):

The 2.5km AROME-Aut system serves as one major backbone for operational forecasts and warnings and for several downstream models and applications. The main characteristics of AROME-Aut can be seen in Table 1 below.

Domain		Model characteristics		LBC	
Grid points:	600x432	Code version:	cy40t1	Coupl. model:	IFS
Horizon. resolution:	2.5km	Time step:	60s	Coupl. frequency:	1h
Levels:	90	Integration time:	60h (00,03,....21 UTC)	Retrieval:	Internet/
Grid:	linear	Physics:	AROME/Meso-NH		RMDCN
Orography:	mean	Dynamics:	non-hydrostatic		
		Initialization:	CANARI/OIMAIN		
			3DVAR		

Table 1: AROME-Aut operational setup

C-LAEF (2.5 km)

C-LAEF (Convection Permitting - Limited Area Ensemble Forecasting) has been developed at ZAMG and is an AROME-based EPS operated at the ECMWF HPC facility. C-LAEF has a horizontal resolution of 2.5km and is running four times a day with two long runs (+60h for 00 UTC, +48 for 12 UTC) and two short runs (06 and 18 UTC) to close the 6h assimilation cycle. The main characteristics of C-LAEF can be seen in Table 2 below.

Domain		Model characteristics		LBC	
Grid points:	600x432	Code version:	CY40T1	Coupl. model:	ECMWF-EPS
Horizon. resolution:	2.5km	Time step:	60s	Coupl. frequency:	3h
Levels:	90	Integration time:	60/48h for 00/12 UTC run		
Grid:	linear	Physics:	AROME/Meso-NH incl.	Archive:	local + MARS (with 2020)
Orography:	mean		HSPP (stoch. Scheme)		
		Initialization:	EDA + surface EDA		
			Ensemble JK		
		Ensemble size:	16 perturbed + 1 control		

Table 2: C-LAEF operational setup

AROME-RUC (1.2 km):

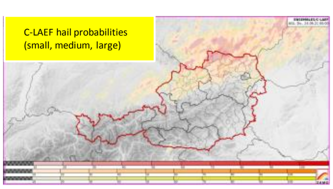
A nowcasting version of AROME is running operational at ZAMG since 2019. The AROME-RUC system runs with an hourly 3D-Var, Latent Heat Nudging of INCA precipitation analyses and forecasts and FDDA nudging of surface stations (T2m, RH2m, u/v10m). Also additional observations like MODE-S, GNSS-ZTD and RADAR are integrated into the system. Compared to the AROME-Aut system, most improvements can be seen for forecasts of precipitation, 10m wind and gusts.

Domain		Model characteristics		LBC	
Grid points:	900x576	Code version:	cy40t1 +	Coupl. model:	AROME 2.5
Horizon. resolution:	1.2km	Time step:	30s	Coupl. frequency:	1h
Levels:	90	Integration time:	12h 24x	Retrieval:	local
Grid:	linear	Physics:	AROME/Meso-NH		
Orography:	mean	Dynamics:	non-hydrostatic		
		Initialization:	CANARI/OIMAIN		
			3D-VAR+LHN+FDDA		
			IAU		

Table 3: AROME-RUC operational setup

Modellperformance in severe weather events 2021:

1) Severe hail in Austria (Czech tornado) 24/06/2021:



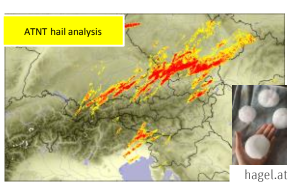


Fig. 1: Probability for large hail from C-LAEF (left) and analysed hail from the ATNT-system.

- C-LAEF with strongest indication of large hail in summer 2021
- Maximum hourly windgusts exceed 100 km/h in parts of Aut/Sk/Cz

2) Flood event 17/07/2021:

- Upslope precipitation along northern Alps, local convection in flatlands
- Numerous stations reported precipitation > 100mm/48h

- Upslope precipitation generally well forecasted
- convection in flatlands hardly
- predictible

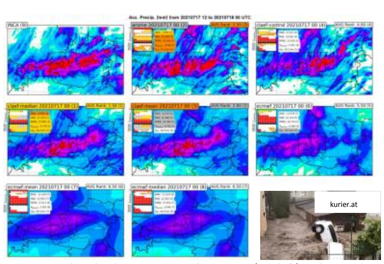


Fig. 2: Analysed 12h precipitation from INCA (top left) and several model forecasts (AROME-Aut, CLAEF, ECMWF) including ranking.

2. Explore new observations for NWP assimilation

The availability of rapidly processed observations with a high temporal and spatial resolution is crucial for the performance of a NWP-based nowcasting system. Hence several projects that investigate the usage of new/alternative observations in AROME-RUC are on-going at ZAMG. In addition new sources of observations are explored for the usage in AROME-Aut/CLAEF as well.

ZTD processed from GNSS receivers on trains:

Currently more than 1000 trains of Austrians federal railway company (OEBB) are equipped with GNSS receivers, providing the potential of significantly increase the available number of ZTD observations in the future. First evaluations of ZTD retrievals with ERA5 (PhD Aichinger-Rosenberger, TU-Vienna) showed that differences of ZTD are in the range of few mm but can exceed the cm-range in some cases.

Rain Rate Information from Microwave Links

The Project LINK is a collaboration between ZAMG, Drei Hutchison, and the FH St. Pölten. The aim is to explore the use of microwave link data to obtain precipitation measurements. Such links connect cell phone towers to each other, and the signals are attenuated by rain between the start and end point of the connection.
The signal attenuation is used to calculate rain rates between cell phone towers and the derived rain rates are planned be used to feed INCA and obtain gridded precipitation data or they can be assimilated into AROME as a point observation at the mid point between the two towers.

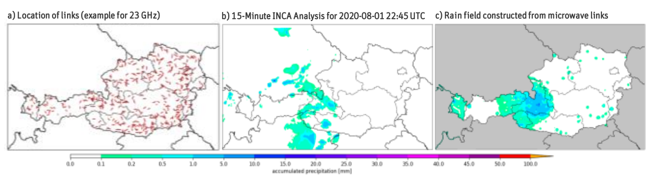


Fig. 3: Locations of the 23 GHz links in Austria (a), INCA analysis of the 15-minute accumulated rain (without links) (b) and data obtained from microwave links using the RAINLINK python package[1] (c). Information from links is not available outside of Austria.

Precipitable Water Vapor from Sentinel-1

The project ACHILLES aims to develop new meteorological products based on Sentinel-1 (S1) data and the SAR interferometry technique. Times series of Precipitable Water Vapor (PWV) maps will be generated based on the excess path delays in S1 interferograms and measurements provided by meteorological stations and GNSS receivers. These S1 PWV maps, characterized by a high spatial resolution, are assimilated in AROME.

3 Surface Layer Index (IFAC)

The orographic nature of Austria with the Alps in the western part and relatively flat areas in the east necessitates a more detailed view on model performance (eg. Fig 4).
To classify model grid points by their orographic location an adapted version of Haiden et al (2011) is implemented and reads:

$$I_{IFAC} = max\left(-1, \quad min\left(0, 0 - \frac{\overline{z_{Ha}} - z_H - z_s}{z_s}\right)\right),$$

$$I_{IFAC} = max\left(0, \quad min\left(\frac{\overline{z_{Hb}} - z_H - z_s}{z_s}, 1\right)\right)$$

$\overline{z_{Ha}}$ and $\overline{z_{Hb}}$ represent average altitude of gridpoints within a given radius which are located above/below the center point z_H. z_s is a tuning factor to reduce noise in the flatlands. Depending whether the number of stations in the surrounding are above or below the center point the first or second formular is used. The surface layer index takes positive values for mountains, 0 for flat areas and negative values for valleys (Fig. 5).

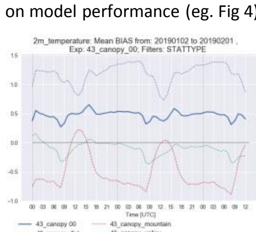


Fig. 4: BIAS of 2m temperature for AROME-Aut. Blue line includes all Austrian stations, for dashed lines only stations on mountains, valleys and flatlands, according to IFAC, are considered.

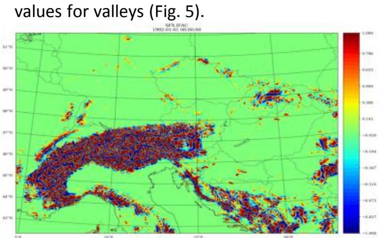


Fig. 5: Surface layer index based on AROME-Aut orography

There are a number of applications where the surface layer index can be applied, eg in station classification for verification, special behaviour of model diagnostics or in post-processing. Currently tests using the surface layer index in 2m diagnostics are ongoing at ZAMG.

[1]Overeem, A., Leijnse, H., and Uijlenhoet, R., 2016: Retrieval algorithm for rainfall mapping from microwave links in a cellular communication network, Atmospheric Measurement Techniques, 9, 2425-2444, https://doi.org/10.5194/amt-9-2425-2016